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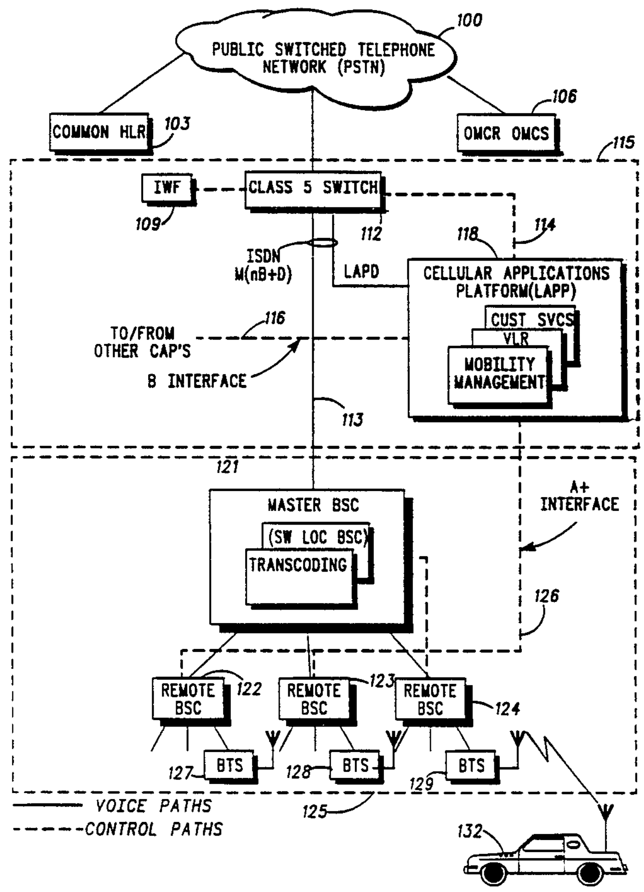
(54) Title: RADIOTELEPHONE SYSTEM CONTROLLER

(57) Abstract

A controller (118) controls functions related specifically to radiotelephone signalling in a communication system. The controller (118) is physically dislocated from a switch (112) which performs all necessary routing of voice information from radiotelephone system-to-radiotelephone system and radiotelephone system-to-public switched telephone system (PSTN, 100). The controller (118) interfaces the switch (112) via an ISDN-type connection, essentially accessing the switch (112) transparently. This transparent access allows for common, generic switches (Class 5 switches for example) having predetermined user features such as Call Waiting, 3-Way Calling, etc. to be employed. Users of the radiotelephone system (125), via radiotelephone signalling processing by the controller (118), can access and utilize the predetermined features of the switch (112) as required.



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RADIOTELEPHONE SYSTEM CONTROLLER

Field of the Invention

The present invention relates generally to radiotelephone systems and, more particularly, to radiotelephone systems incorporating switches to perform communication interconnection between elements of the radiotelephone system.

Background of the Invention

Radiotelephone systems typically incorporate radiotelephone-specific switches which are used to interconnect base-stations in a particular coverage area with a public switched telephone network (PSTN). These radiotelephone-specific switches perform switching in response to signalling aspects related to the radiotelephone system. For example, the radiotelephone-specific switch may be the central location for storage of subscriber identification numbers, visiting identification numbers, billing information, etc. When a radiotelephone call is initiated by a subscriber unit to a particular base-station in the radiotelephone system, the base-station will report the appropriate information back to the radiotelephone-specific switch so that switching to the appropriate destination can occur. Likewise, the radiotelephone-specific switch will perform user billing computations and storage, among other things.

The radiotelephone-specific switches used in radiotelephone systems are difficult to build and even more difficult to maintain due to the complex combination of the switching elements coupled with the radiotelephone-specific aspects of signalling, control, etc. Also, since the upper limit of capacity with respect to the radiotelephone-specific switch is usually the upper limit of capacity

of the radiotelephone system for a given coverage area, a practical subscriber capacity problem occurs when radiotelephone-specific switches are employed. In typical scenarios, the subscriber capacity for radiotelephone-specific switches may range anywhere from 500 subscribers up to at least 2500 subscribers, depending on the coverage area. In large coverage areas, the upper limit of subscriber capacity given by these radiotelephone-specific switches can be exceeded in a very short time.

To alleviate this capacity and complexity problem in radiotelephone systems, elimination of the radiotelephone-specific switch is an ideal solution. Moreover, since land-line switches are abundant throughout the PSTN, there should never be a lack of switching power which might be used for both PSTN-type switching and radiotelephone-type switching. To eliminate the radiotelephone-specific switch, the signalling aspects related strictly to the radiotelephone system need to be removed from the radiotelephone-specific switch. This would allow for generic, PSTN-type switches to be used in lieu of the complex and capacity-limiting radiotelephone-specific switches. To assure a transparent change-over from the radiotelephone-specific switches to PSTN-type switches, changes to the architecture of the PSTN-type switch should be kept to a minimum. For example, if a controller containing only radiotelephone signalling aspects is to be connected to the PSTN-type switch, the controller should not require additional protocol to perform the appropriate switching between the radiotelephone system and the PSTN. In other words, the controller should have the capability to interface into a standard port of the PSTN-type switch without the switch knowing that it is being used for radiotelephone-type switching. In addition, the controller, and consequently the radiotelephone system, should have appropriate capability to leverage off of existing, classical PSTN-type switch functions.

Thus, a need exists for a radiotelephone system which essentially separates the functions of radiotelephone-type signalling aspects from the switching aspects, and in addition leverages off of existing PSTN-type switches for call features and consequently, user convenience.

Summary of the Invention

A controller in a communication system processes control information related only to the radiotelephone system and accesses a switch to appropriately route voice information responsive to the processed control information.

Brief Description of the Drawings

FIG. 1 generally depicts the topology of a communication system incorporating a switching center having separate switching functions and radiotelephone signalling processing in accordance with the invention.

FIG. 2 generally illustrates in block diagram form the cellular applications platform (CAP) in accordance with the invention.

FIG. 3 generally depicts the steps the communication system of FIG.1 undergoes to connect a mobile initiating a call to a land-line destination within the PSTN in accordance with the invention.

FIG. 4 generally depicts the steps the communication system of FIG. 1 undergoes to connect a PSTN-originated call to a mobile in accordance with the invention.

FIG. 5 generally depicts the steps the communication system undergoes to perform location update in accordance with the invention.

Detailed Description of a Preferred Embodiment

FIG. 1 generally depicts the topology of a radiotelephone system having separate switching functions and radiotelephone signalling aspects in accordance with the invention. In the preferred embodiment, the switch is a Class 5 switch 112. Also, in the preferred embodiment the radiotelephone system is a cellular radiotelephone system, and more specifically the Group Special Mobile (GSM) Pan-European Digital Cellular System, which is generally described in GSM Recommendation 1.02, version 3.0.0, March, 1990. The concept, however, may be applied to any radiotelephone system which incorporates a radiotelephone-specific switch, such as an EMX switch available from Motorola, Inc. and described in Motorola Instruction Manual No. 68P81054E59 published by Motorola Service Publications, Schaumburg, IL. Continuing, FIG. 1 depicts a virtual mobile switching center 115 (MSC). In this architecture, the MSC 115, formally a distinct and separate entity, has evolved to a network of base-station controllers 125, a home location register 103 (HLR), a cellular application platform 118 (CAP) with cellular specific functions, and a set of defined standard interfaces for network interconnect functionality, plus specially developed (and published) interfaces for local cellular control, and a comprehensive operations & maintenance center 106 (OMC) element for managing this virtual MSC configuration. In addition, the virtual MSC will connect to any manufacturers Class 5 central office switch that provides a minimum set of intelligent networking (IN) capabilities.

The concept depicted in FIG. 1 assumes that the PSTN Class 5 switch services, over a combination of Primary Rate Interfaces (PRI) and Basic Rate Interfaces (BRI) with SS7 & IN capabilities, will allow incorporation of many of the Class 5 switch 112 features currently, or soon to be available. Significant to note is that the

typical growth limitation of cellular switching systems today, the radiotelephone-specific switch (the MSC in the GSM Digital Cellular System), is no longer a factor in the architecture depicted in FIG. 1. The switching limitations of the virtual MSC 115 are borne solely by any Class 5 office switching limitations.

The CAP 118 would support a combination of cellular specific functions that could reside on a single or multiple platforms as a function of cost and performance. In fact, some of the elements shown as distinct and separate entities, i.e., vehicle location register (VLR), mobility management, customized services, etc., could co-reside on the same physical platform if cost and performance warrant this arrangement. However, functionally these elements are shown separately to focus on their particular function within the virtual MSC 115. The CAP 118 could have the capability to address the small as well as the large market, ranging from 50 channels to 6,000 channels. Expansion beyond that figure is envisioned to be performed through networking of CAPs 118 via the B interface 116 of FIG.1.

The HLR 103 represents the subscriber data base for the cellular network and is the permanent record store for all subscribers in the network. The HLR 103 contains information such as preferred carrier, allowed features, call screen list, etc. This platform is also extensible in that the number of subscribers ranges from a low end of approximately 5,000 subscribers to a high end of approximately 500,000 subscribers. Physically, the HLR 103 interconnects to the network or Class 5 switch 112 via SS#7 to facilitate incoming calls, and connects to the CAP 118 via IS-41, or GSM MAP, to support validation.

The base-station controllers 121-124 (BSC's), which may be local or remote, all have subrate switching capability within the platform and primarily perform interfacing functions for the radiotelephone system 125 to the virtual MSC 115. Each BSC supports a plurality of base transceiver stations 127-129 (BTS's),

which are the actual radio channels used to communicate with a subscriber 132. Whenever possible, speech compression may be employed between the BTS and BSC to reduce line costs. Handoff between BTS's under the same BSC are accomplished via the switching capability associated with the BSC 122-124. Handoffs between BSC are accomplished through the Class 5 switch 112, typically via nailed connections. Alternatively, direct connections between BSC's may be used to facilitate the inter-BSC handoff. In the preferred embodiment, each BSC 121-124 is targeted in size to support up to 1,500 radio channels.

The transcoder function, depicted in the master BSC 121 of the radiotelephone system 125, is present to allow voice compression for decreased back haul costs on cell site connections. In the preferred embodiment, transcoding converts 13 Kbps GSM speech to 64 Kbps A-Law PCM. The transcoding function also represents the termination point for the integrated services digital network (ISDN) interface with the Class 5 switch 112. If desired for cost purposes, switching may also be associated with the transcoder to facilitate inter-BSC connections. The Class 5 switch 112 link 113 terminates on the transcoder in the master BSC 121, where D channel controllers are groomed and routed to the CAP 118. Voice channels are then compressed, if necessary (most analog modulation schemes do not use compression today), and routed to the BSC's 122-124.

The BSC's 121-124 communicate with the CAP 118 through the A+ interface, which is an interface based on the GSM A interface. The A+ interface must supplement to the A interface to support analog modulation schemes as well as future digital modulation schemes, and is a published interface. The physical realization of this interface would most likely result in the transcoder grooming this interface from the BSC voice terminations and routing it to the CAP 118 with the D channel terminations.

All inter-switch communications shall be handled by yet another published interface. In the preferred embodiment, this interface would be the GSM MAP interface. In countries such as the United States, the interface would be IS-41 interface. Inter-switch handoffs, as well as call delivery, would be facilitated through this interface. Voice interconnect to other switches would be made through the Class 5 switch 112, with control riding in the same link.

All the elements comprising the virtual MSC 115 will require interconnection to the OMC 106. The OMC 106 represents a common look and feel to the operator for the entire infrastructure, and provides a central location for operation and maintenance type monitoring and performance. Interconnection to the PSTN 100 will be via a X.25 link with a standardized CMISE protocol. In addition, an interworking function 109 (IWF) is connected to the Class 5 switch 112 to facilitate bearer services such as FAX, modem services, etc.

As previously mentioned, the Class 5 switch 112 may be a generic Class 5 switch that supports the following functionality:

1. <u>End Office Service Switching Point (SSP)</u>, e.g., 800 type message query service. the SSP function must be able to route a SS7 formatted message to either or both the service control point (SCP) like functions of the HLR 103 and the CAP 118 entities.
2. <u>Primary Rate Interface (PRI)</u>, the PRI is Q.921/Q.931 based. 23B+1D is sufficient for the virtual MSC 115 approach.
3. <u>Basic Rate Interface (BRI)</u>, the Q.931/Q.932 message set for the BRI is the support protocol required for this interface.

4. SS7 Trunking, the Class 5 switch 112 should be able to terminate SS7 trunking to the local exchange carrier within the PSTN. Support of customized local area signalling services is desirable for future feature inter-operability.
5. CLASS Features, support of CLASS is desirable for future feature inter-operability.
6. ISDN/SS7 Interworking, it is desirable to have PRI/SS7 call set-up and data transport available on the Class 5 switch 112.

As depicted in FIG. 1, the SS7 link 114 connecting the Class 5 switch 112 to the CAP 118 relates to a number of the International Telegraph and Telephone Consultive Committee (CCITT) recommendations. The CCITT recommendations pertain to signalling in telephone networks for the purposes of call control and set-up as well as information exchange for peripheral services related to telephony. Communications between the CAP 118, the HLR 103, and the Class 5 switch 112 are covered under several component parts of SS7, while the voice signalling for SS7 trunks between Class 5 switches and between Class 5 and Class 4 switches are covered under a slightly different grouping of component capabilities. Generally, the CAP 118/HLR 103/Class 5 switch 112 communications requires the message transfer part (MTP), signalling connection control part (SCCP), combined with transaction capabilities procedures (TCAP) to support query and response type messages (800 like services) between network elements. The voice communication between the switches require the MTP and either the telephone user part (TUP, international only), or the integrated services digital network user part (ISUP). While variations on all of the above exist in terms of operations and services, it is the TUP/ISUP components that are most often

country variant to a non-capable status with other countries implementations.

Interconnection between CAPs 118 from system-to-system is accomplished via the B interface 116 depicted in FIG.1 The B interface 116 comprises the inter-MSC IS-41 call sequence functionality for inter-MSC functions, e.g., registration, validation, handoff, updates, etc., plus the voice grade trunking (SS7 preferably) to deliver the calls to another Class 5 switch that hosts the targeted MSC. The B interface 116 used in the preferred embodiment provides these functional capabilities under the GSM mobile application part (804 and 808). Again, it is desirable that the inter-switch voice call delivery be the SS7 trunking.

Referring to FIG. 1, the CAP 118 is best described in terms of three basic functional blocks. These functions, and an accompanying description are listed below.

Mobility Management - this entity arbitrates over all the handoff processing in the system. All measurement coordination, routing, control, etc., are under the jurisdiction of this entity. In addition, basic call-control would reside in this entity.

VLR - this entity is responsible for tracking the location of the mobile 132 in the geographical coverage area covered by the BSCs residing under a particular CAP. As shown in FIG. 1, these would relate to BSCs 121-124 under the control of CAP 118. All registration processing, etc., is managed in this entity. In addition, all logical mobile busy status is maintained in this functional block.

Custom Services - this entity represents the remaining unique features of cellular, such as call trace, air time billing, etc. It also represents a customer programmable platform in that this is the main manifestation if the so called service creation environment for the virtual MSC 115.

Significant to note is that the physical implementation of the CAP 118 may result in multiple platforms or in a single platform depending on the size, modulation scheme and environment chosen. The software to perform the functions described shall be architected in such a fashion as to support the flexible hardware architecture. The CAP 118 will be required to support X.25 as well as SS7 signalling links.

FIG. 2 generally depicts the hardware architecture of the CAP 118 in accordance with the invention. A front-end 200 is coupled to a compute platform (CP) 221 via a redundant I/O interface bus 215. Front-end 200 uses processed control information for accessing switch 112 and routing voice information through the system. The front-end 200 essentially consists of digital hardware located in the BSCs 121-124. The front-end 200 consists of generic processors 203 (GPROC) which provide the interface capability and the hardware to support the B interface 116 depicted in FIG. 1. The GPROC 203 is generally comprised of a Motorola 68030 digital signal processor (DSP), up to 16 Mbytes of RAM, approximately 2 Mbytes of EPROM, 8 Kbytes of NVRAM, dual IEEE 802.2 local area network (LAN) interfaces, 32-64KBPS LAPB/D serial interfaces 209, dual TDM switch highway interfaces to support the redundant TDM highway, 4 asynchronous/synchronous serial ports, and dual MCAP bus 205 interfaces to support the redundant MCAP bus 205. The GPROCs 203 are coupled to a mega-stream interface 206 (MSI) which provide a circuit interface for the 2.048 MBPS spans (the A+ interface 126 of FIG. 1) which are coupled to the BSCs 121-124 of

FIG. 1. The front-end 200 provides the digital hardware necessary to interpret and appropriately route incoming signalling-type messages to the CP 221 which processes the control information.

When messages are received by the CP 221, the appropriate action is invoked by the software used by the CP 221. A storage medium 224 is used to store user information, and may specifically be used to store information related to customer services, vehicle location registration, and mobility management. When the CP 221 has completed processing messages from the front-end 200, the CP 221 will transmit the appropriate response message back to either other CAPs, the Class 5 switch 112, or the BSCs 121-124. This is done via the front-end 200. Typical messages processed by the CP 221 may be to establish a call connection to a subscriber 132, perform a handoff from one subscriber to another, etc. In the preferred embodiment, the CP 221 and the storage medium 224 contain only processing capability related to the radiotelephone system. In addition, the CP 221 only processes control data it receives from other CAPs, the Class 5 switch 112, or the BSCs 121-124; no voice information is ever routed through the CAP 118.

FIG. 3 generally depicts the steps the communications system of FIG. 1 undergoes to connect a subscriber unit 132 initiating a call to a land-line destination within the PSTN 100 in accordance with the invention. To begin the call sequence, the mobile 132 sends an origination sequence to the BSC it is being served by. Referring to FIG. 1, this BSC is remote BSC 124 for purposes of example. The BSC 124 sends a service request to the LAC surface request which includes the origination information from the mobile 132. The LAC transmits the CM service request to the CAP where transaction 301 occurs. Transaction 301 includes call processing in the CAP 118. In addition, data storage is initialized, and all pertinent information from the mobile 132 is recorded. This information includes: seizure time, mobile identity, circuit information, etc. The CAP 118 also updates trunk statistics

and initiates dialog with the VLR to obtain appropriate parameters. The VLR validates the mobile and returns a service profile back to the CAP 118. Transaction 302 validates the response from the VLR and routes the response to the CP 221 of the CAP 118. The CP 221 of the CAP records all pertinent mobile 132 information, which includes authentication, ciphering, and temporary mobile subscriber identity (TMSI) data. The CAP 118 then initiates authentication by sending an authenticate message to the mobile 132 via the LAC and the BSC 124. The mobile 132 then returns an authentication response back to the CAP 118 via the BSC 124 in the LAC. Transaction 303 occurs at the CAP 118 by routing the authentication response to the compute platform of the CAP 118. The compute platform 221 verifies the response and then initiates ciphering by sending a cipher message to the mobile 132. The mobile 132 processes the cipher message and sends a cipher response back to the CAP 118 via the BSC 124 and the LAC. Transaction 304 occurs by routing the cipher response to the CP 221 where the response is verified. The CAP 118 then initiates TMSI processing by sending TMSI to the mobile 132 via the LAC and the BSC 124. The mobile processes the TMSI message and returns a TMSI response to the CAP 118. Transactions 305 occurs when the TMSI response is routing to the CP 221 of the CAP 118. The CP 221 of the CAP 118 verifies the response then awaits the message from the mobile 132. Upon receipt of set up of message from the mobile 132, transactions 306 routes the set up message to the CP 221 of the CAP 118. The CP 221 sends the dialed digit to be translated, the number translation receives the digits and translates (using DB routines), the results are returned and translation results received by CP 221. A set up of the message is then sent to the term call handler, call processing is initiated by the CAP 118, and a BRI trunk is selected via a message sequence with a trunk handler. Call sequence queue .931 then begins and the cap 118 establishes the call by send a set up message to the Class 5 switch 112 via the LAC.

The Class 5 switch 112 then sends an initial address message (IAM) to the PSTN 100 and then sends a call proceeding message back to the CAP 118 via the LAC. Transaction 307 occurs at the CAP when the call proceeding message from the Class 5 switch 112 is routed to the CP 221 for processing. A call proceeding message is then sent to the mobile 132 by the CAP 118 via the LAC and the BSC 124. The CAP 118 then obtains a terrestrial circuit the message transaction and sends an assignment command to the BSC 124 and the mobile 132. The BSC 124 sends an assignment complete command back to the CAP where at transaction 308 it is routed to the CP 221. The CAP 118 then sends a path connect order to the LAC.

The LAC makes the path connect between itself and the CAP 118. The PSTN 100 the sends an ACM message to the Class 5 switch 112 which in turn sends an alerting message to the CAP 118 via the LAC. Transaction 309 routes the incoming alerting message from the Class 5 switch 112 to term call processing in the CAP 118 which records the event and passes the alerting the message to the CP 221. The CP 221 sends an alerting message to the mobile 132 via the LAC and the BSC 124. At this time, the PSTN 100 sends an answer message to the Class 5 switch 112 which then sends a connect message to the CAP 118 via the LAC. Transaction 310 then routes the incoming connect message to term call processing which records the event and passes the connect message to the CP 221. The CP 221 in the CAP 118 records the answer time, updates statistics, and then sends a connect message to the mobile 132. The call is now in the conversation state.

The call will continue until either party elects to discontinue it. Upon discontinuance, the PSTN 100 sends a release message to the Class 5 switch 112 which simultaneously sends a release call (RLC?) to the PSTN 100 and a disconnect message to the CAP via the LAC. Transaction number 311 routes the disconnect message to term call processing which records the call disconnect time and

then forward the message to the CP 221. The CP 221 of the CAP 118 then initiates a disconnect sequence by sending a disconnect message to the mobile 132 via the LAC and the BSC 124. The mobile 132 sends a release response back to the CAP where transaction 312 routes the release response to the CP221 of the CAP. The CP 221 of the CAP records the release time and acknowledges the release by sending a release complete message to the mobile via the LAC and the BSC 124. The release message is forwarded to term call processing within the CAP 118 which then acknowledges to the Class 5 switch 112 the release by sending it the release message. The Class 5 switch acknowledges the release by sending a release complete message back top the CAP 118 where transaction 313 routes the release complete message to term call processing. Term call processing idles the BRI via a message exchange and sends term call segments to the billing generator. The term call processing forward the release complete message to the CP 221 of the CAP 118 and then terminates the operation. The CP 221 sends a clear command to the BSC while the CP 221 stores a segment of billing information and awaits for the completion of the billing information. The BSC 124 sends a channel release message to the mobile 132 wherein the mobile will stop transmitting on the particular channel. When this occurs, the BSC 124 will send a clear complete message to the CAP 118 where transactions 314 routes the clear complete message to the CP 221. At this time, terrestrial circuits that were previously engaged are released the message transaction, the time recorded and the remaining segments of billing information sent to the billing generator. Original call processing ends, the billing generator formulates and sends the billing and data to the VLR. The VLR sends an acknowledgement back to the CAP 118 where transaction 315 is routed to the billing generator within the CAP 118 and call data is then released.

FIG. 4 generally depicts the steps the communication systems undergoes to connect a PSTN-originated call to a mobile, the mobile answers, and the mobile disconnects first in accordance with the invention. To begin the call, the PSTN 100 sends an initial address message (IAM) to the Class 5 switch 112. The Class 5 switch 112 then sends routing information to the HLR 103 which then in turn sends the routing information to the VLR within the CAP 118. In the preferred embodiment, the VLR resides within the CAP 118. In other embodiments, the VLR may be a separate physical entity. Continuing, the incoming routing information is received by the CAP and transaction 401 routes the information to original call processing within the CAP 118. At this time, a BRI is allocated via a message sequent and a timer is set within the CAP 118. The routing information acknowledgement containing a mobile station roaming number (MSRN) associated to the BRI is returned to the VLR and a set up message is awaited. The VLR sends the routing information acknowledgement to the HLR 103 where it is in turn sent to the Class 5 switch 112. The Class 5 switch 112 sends a set-up message to the CAP 118 via the LAC where transaction 402 routes the set up message to original call processing within the CAP 118. At this time, the CAP 118 records the seizure time and pegs statistics. Also, the original call processing within the CAP 118 matches the incoming BRI with the subscriber number. This data is passed to term call processing in a modified set up message; term call processing initializes data processing data storage, records all pertinent information, such as mobile identity, circuit information, etc. and initiates a dialog with a VLR to obtain location area identification (LAI), TMSI, and international mobile subscriber identity (IMSI). The CAP 118 then sends a validation request to the VLR to validate the mobile. The VLR then sends a validation response containing the LAI, TMSI, and IMSI back to the CAP 118 where transaction 403 routes the validation response to term call processing within the CAP 118.

Call processing within the CAP 118 records all the pertinent information and initiates a paging sequence. The CAP 118 pages the mobile 132 via the lack and the BSC 124 through BTS 129. The mobile 132 sends a page response back to the CAP 118 via the BSC 124 and the LAC where transaction 404 routes the incoming page response to term call processing within the CAP. Term call processing records all pertinent information about the mobile 132 and sends a process access request message to the VLR. The VLR sends authenticate, cipher, new TMSI data back to the CAP where transaction 405 routes the incoming access response to term call processing within the CAP 118. Term call processing records this information then initiates authentication by sending an authentication message to the mobile 132. The mobile 132 will send an authentication response back to the CAP 118 where transaction 406 routes the authentication response to term call processing. Term call processing verifies the response and then initiates ciphering by sending a cipher message to the mobile 132. Upon receipt of the cipher message, the mobile will send a cipher response back to the CAP 118 for transaction 407 routes the cipher response to term call processing. Term call processing verifies the response and then the CAP 118 initiates TMSI processing by sending TMSI to the mobile 132. The mobile 132 sends a TMSI response back to the CAP 118 where transaction 408 routes the incoming TMSI response to term call processing within the CAP 118. Term call processing verifies the TMSI response and begins the Q.931 sequence. The CAP 118 establishes a call to the mobile 132 by sending a set up message to the mobile 132 via the LAC and the BSC 124.

At this time, the mobile 132 sends a call confirmation message to the CAP 118 where transaction 409 routes the message to term call processing within the CAP 118. The CAP obtains terrestrial circuits via message transactions and sends assignment commands to the BSC 124 and the mobile 132. Also, at this time, the

CAP 118 records all pertinent data required for billing purposes. Upon receipt of the assignment command, the mobile 132 will send an assignment complete message back to the CAP 118 via the BSC 124 and the LAC. Transaction 410 routes the incoming assignment complete message to call processing after sending the assignment complete message, the mobile 132 sends an alert message back to the CAP 118 where transaction 411 routes the alert message to term call processing. Term call processing within the CAP 118 records the events and forwards it to the original call processing, where it is then sent to the Class 5 switch 112 via the LAC. The Class 5 switch 112 sends a ACM message to the PSTN 100 while the mobile 132 sends a connect message to the CAP 118. Transaction 412 routes the incoming connect message from the mobile 132 to term call processing within the CAP 118. Term call processing within the CAP 118 (where is term call processing, is it the compute platform 221) records the event, time, and passes message to original call processing which sends a path connect order to the LAC. Original call processing then sends a connect message to the Class 5 switch 112 via the LAC. The Class 5 switch 112 sends a ANS message to the PSTN 100. The Class 5 switch 112 also sends a connect ACK message back to the CAP 118 via the LAC where transaction 413 routes the connect ACK message from the Class 5 switch 112 to original call processing. Original call processing records the answer time and forwards the message to term call processing. Term call processing sends the connect ACK message to the mobile 132 via the BSC 124 and the BTS 129 which places the call into the conversation state.

The call will stay in the conversation state until either the user on the PSTN 100 side or the mobile 132 decides to terminate the call. If the mobile 132 initiates the termination, it will send a disconnect message to the CAP 118 where transaction 414 routes the disconnect message to term call processing. Term call processing records the disconnect time and forwards the message

to original call processing which in turn initiates a disconnect sequence by sending the disconnect message to the Class 5 switch 112 via the lack. The Class 5 switch 112 sends a REL message to the PSTN 100 which in turn sends a RLC message back to the Class 5 switch 112. In the meantime, the Class 5 switch sends a release message to the CAP 118 via the lack where transaction 415 routes the release message to original call processing. The CAP records the release time and forwards the release message to term call processing which then sends the release message to the mobile 132. The mobile 132 responds with a release complete command which is received by the CAP 118. Transaction 416 routes the release complete message to term call processing which sends a clear command to the BSC 124 and forward the release complete command to original call processing. Original call processing sends a release complete message to the Class 5 switch 112 via the LAC and then idles the BRI via a message transaction. Original call processing also sends the original call segment to the billing generator and terminates operation. The billing generator stores the call segment and awaits for the other half of the segment. (Where is billing done?). As part of the call termination procedure, the mobile 132, after receiving the clear command from the CAP 118 sends a channel release command back to the BSC 124 which in turn sends a clear complete command back to the CAP 118. Transaction 417 routes the clear complete message from the BSC message 124 to call processing which releases terrestrial circuits via message transactions. The CAP 118 also records the time and sends the other half of the call segment to the billing generator; term call processing ends at this point. The billing generator within the CAP 118 formulates and sends the billing data to the VLR which in turn sends a billing data ACK message to the CAP 118. Transaction 418 routes the billing data ACK message from the VLR to the billing generator within the CAP 118. Finally, the CAP 118 releases all call data.

Still another function, inter alia, that the CAP 118 can be used to perform is location update of a mobile 132. As the mobile 132 moves throughout locations having different area identifiers, the VLR pertaining to that location area, or a different location area, needs to be updated. FIG. 5 generally depicts the steps the communication system undergoes to perform location update in accordance with the invention. Again, when the mobile turns on or enters a new LAI, the steps the mobile 132 takes to establish communication to the BSC 124 are the same as that for IMSI detach and attach. When signalling has been established between the mobile 132 and the BSC 124, the mobile 132 will send a location update message to the capital BSC 124 which in turn transfers this location update message to the CAP 118 via the LAC. Transaction 501 routes the location update message to mobility management within the CAP 118. The CAP 118 then sends an update location area message to the BLR. Important to note here is that the update location area message contains both the old and the new LAIs; also, if the location updates indicates periodic registration, then a new TMSI is not required. Continuing, the VLR sends a return result to the CAP 118 where transaction 502 routes the return result to mobility management within the CAP. The CAP 118 then initiates authentication processing by sending an authentication request to the mobile 132. Upon receipt of the authentication request, the mobile will respond back to the BSC 124 which in turn will send an authentication response back to the CAP 118. Transaction 503 routes the authentication response to mobility management, which verifies the response and initiates ciphering by sending a cipher message to the mobile 132. The mobile responds back to the BSC 124 which in turn sends a cipher response to the CAP 118. Transaction 504 routes the cipher response to mobility management which verifies the response. The CAP 118 then initiates TMSI processing by sending TMSI to the mobile 132. The mobile 132 undergoes a TMSI reallocation sequence with BSC 124 and, upon completion,

the BSC 124 sends a TMSI reallocation complete message to the CAP 118. Transaction 505 at the CAP 118 routes the TMSI reallocation complete message to mobility management which again verifies the response. The CAP 118 then sends a TMSI ACK message to the VLR. The TMSI ACK message contains the appropriate location update. The VLR then sends a location update accepted message to the CAP 118 where transaction 506 routes the location update accepted message to mobility management. At this point, the CAP 118 sends a location update accepted message to the mobile 132 via the LAC and the BSC 124 and also sends a clear command message to the BSC 124. The BSC 124 sends a channel release message to the mobile 132 which response with a DISC command to the BSC 124. The BSC 124 sends a clear complete command to the CAP 118 where transaction 507 routes the message to the mobility manager. At this point, location update of the mobile 132 has been completed.

As can be appreciated by those skilled in the art, FIG.'s 3-5 represent a fraction of the possible message sequences available within a complex radiotelephone system. The advantages, however, of separating the signalling functions related to the radiotelephone system from the switching functions performed by the Class 5 switch 112 are apparent. Since a high percentage of the data transferred throughout the radiotelephone system consists of signalling data related to the radiotelephone system, it is extremely practical for the CAP 118 to perform solely as the "conductor" of all signalling aspects related to the radiotelephone system. This allows the Class 5 switch 112 to solely perform switching functions related to voice information transferred between the PSTN 100 and the radiotelephone system 125. Also significant to note is that the CAP 118 does not require any special interface to access the Class 5 switch 112. Referring to FIG. 1, the control paths between the Class 5 switch 112 and the CAP 118 are standard SS7 links. Likewise, the CAP 118 also is input into the Class 5 switch 112 via a typical ISDN-

type connection, which in the preferred embodiment is a LAP_D connection. In this way, the CAP 118 simply accesses the standard control circuitry found within the Class 5 switch 112. Since Class 5 switches 112 incorporate predetermined features, such as three party conference calling, call waiting, etc., the Class 5 switch 112 is transparent to all signalling provided by the CAP 118. Thus, by accessing the Class 5 switch 112 through a common ISDN-type connection, the cellular radiotelephone system 125 can leverage off of the features provided by a standard Class 5 switch 112. This feature eliminates the need for a special cellular switch which also incorporates the predetermined features required by users of both the radiotelephone system 125 and the PSTN 100.

Claims

1. A controller in a communication system, the controller coupled to at least a switch and a radiotelephone system, the controller comprising:

means for processing control information related to the radiotelephone system; and

means, coupled to said means for processing, for accessing the switch to appropriately route voice information responsive to said processed control information.

2. The controller of claim 1 wherein said means for accessing further comprises means for accessing the switch via an ISDN-type connection.

3. The controller of claim 2 where said means for accessing the switch via an ISDN-type connection further comprises means for accessing a controller disposed within said switch via an ISDN-type connection to appropriately route said voice information.

4. A switching center for interfacing between a radiotelephone system and a public switched telephone network (PSTN), the switching center comprising:

a switch, coupled to the radiotelephone system and the PSTN, for routing user information between the radiotelephone system and the PSTN, said switch having a multiplicity of predetermined features corresponding to services available for access by a user; and

a controller, coupled to at least said switch and the radiotelephone system, for controlling at least signalling and user registration aspects of the radiotelephone system and accessing said predetermined features of said switch when required by said users.

5. The switching center of claim 4 wherein said switch further comprises a Class 5 switch.

6. The switching center of claim 4 wherein said controller further comprises an interface for coupling to a plurality of similar controllers to facilitate handoff in the radiotelephone system.

7. The switching center of claim 4 wherein said coupling between the switch and the controller is accomplished via an ISDN-type connection.

8. A method of call establishment in a communication system, the communication system having a controller coupled to a switch and a plurality of base-stations in a radiotelephone system, the controller physically dislocated from the switch, the method at the controller comprising the steps of:

receiving a call establishment request from a radiotelephone subscriber unit via a base-station;

validating said call establishment request from said radiotelephone subscriber unit;

initiating an authentication procedure to authenticate said radiotelephone subscriber unit when said call establishment request is valid; and

instructing the switch to route voice information from said radiotelephone subscriber unit via said base-station to an originating destination when said radiotelephone subscriber unit is authentic.

9. A MSC in a radiotelephone system comprising:

a switch having user telephony feature capability; and

a processor for providing a radiotelephone functionality;

wherein the radiotelephone functionality of said processor combines with the user telephony feature capability of the switch to provide a virtual MSC in a radiotelephone system.

10. The radiotelephone system of claim 9 wherein said switch is a Class 5 switch.

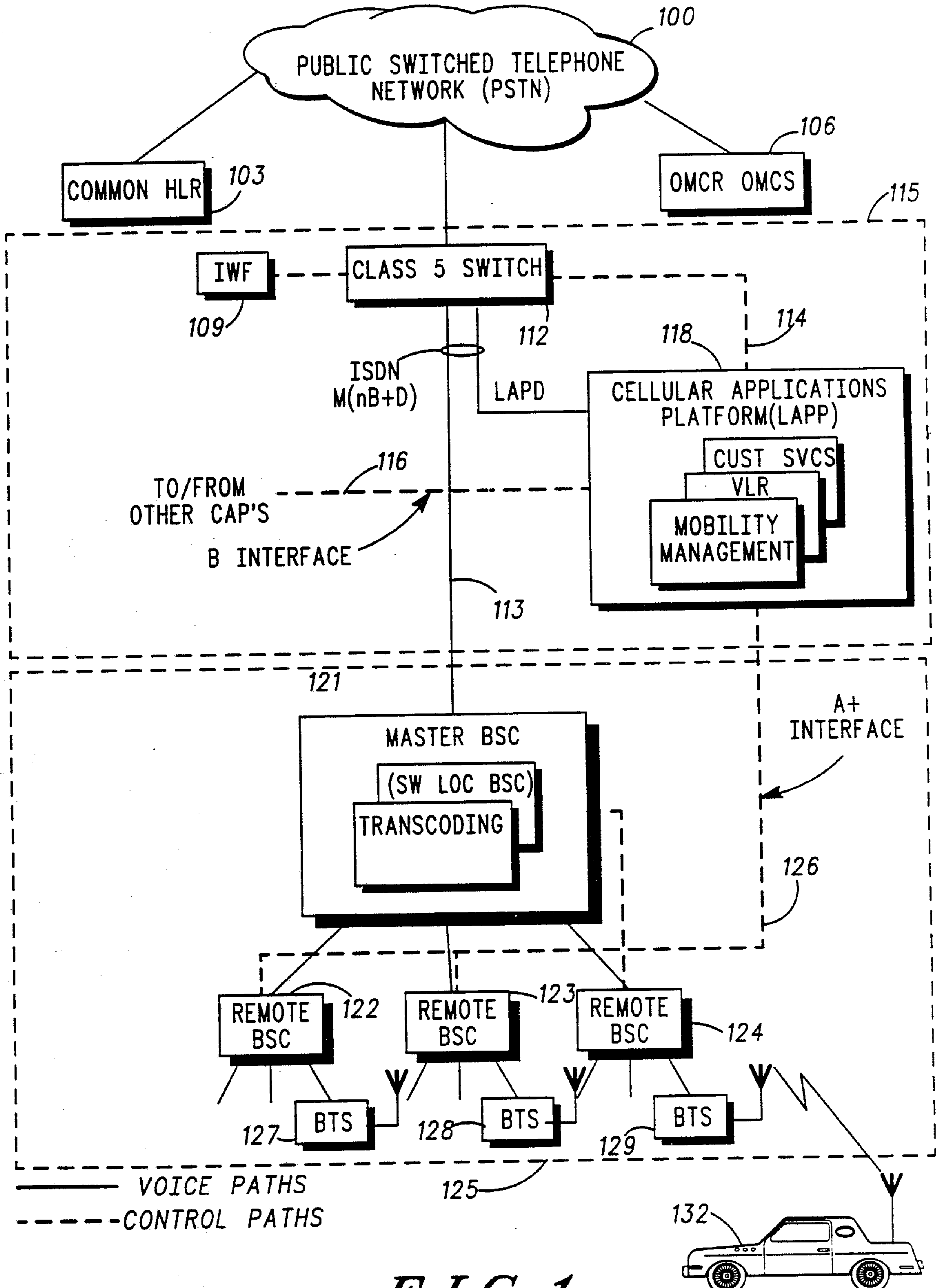

PUBLIC SWITCHED TELEPHONE NETWORK (PSTN)
100
COMMON HLR
103
OMCR OMCS
106
115
IWF
CLASS 5 SWITCH
109
112
114
118
ISDN M(nB+D)
LAPD
CELLULAR APPLICATIONS PLATFORM(LAPP)
CUST SVCS
VLR
MOBILITY MANAGEMENT
116
TO/FROM OTHER CAP'S
B INTERFACE
113
121
A+ INTERFACE
MASTER BSC
(SW LOC BSC)
TRANSCODING
126
REMOTE BSC
122
123
124
BTS
127
128
129
125
VOICE PATHS
CONTROL PATHS
132

FIG.1

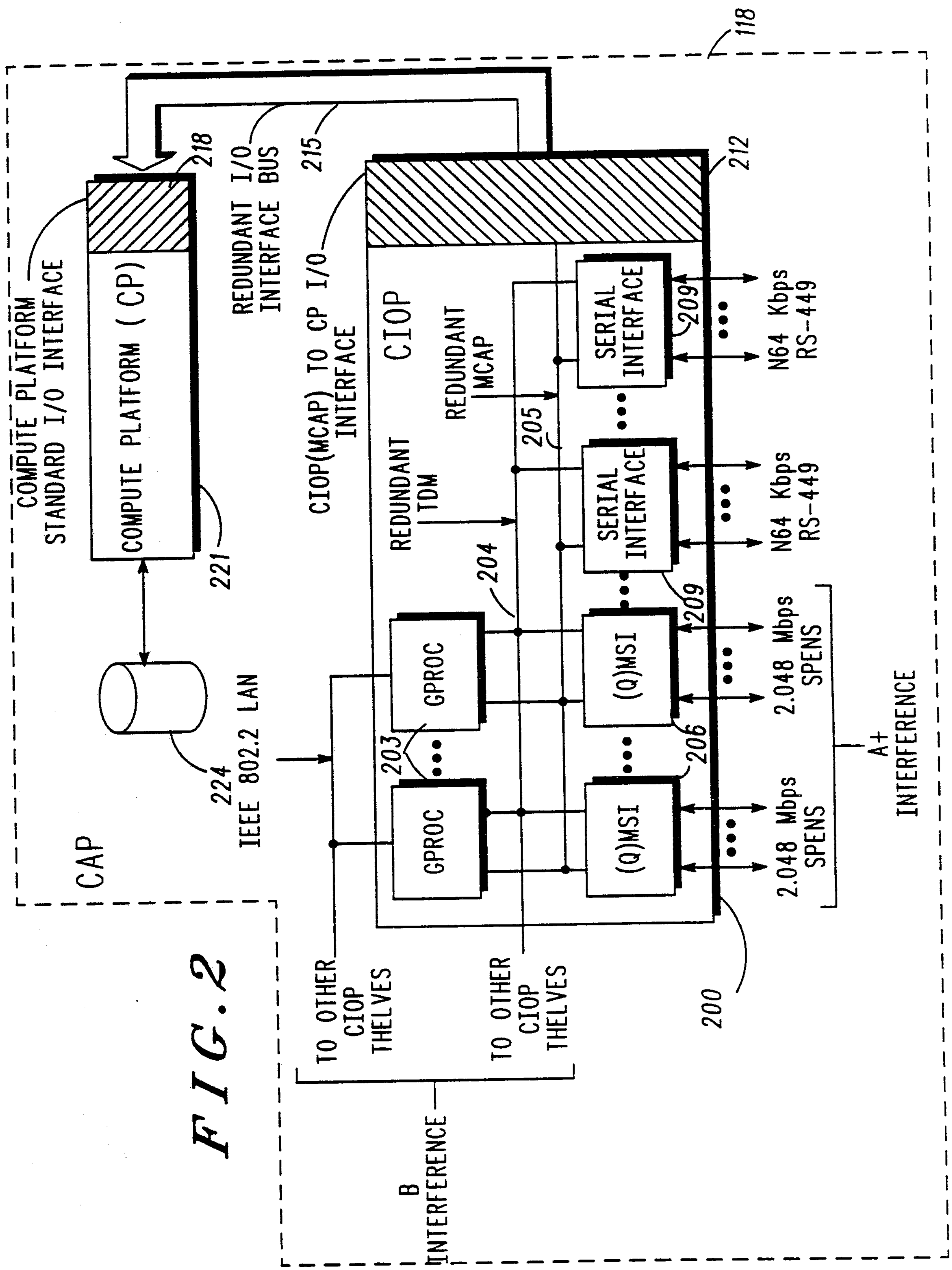

CAP
COMPUTE PLATFORM STANDARD I/O INTERFACE
COMPUTE PLATFORM (CP)
218
221
224
IEEE 802.2 LAN
REDUNDANT I/O INTERFACE BUS
215
CIOP(MCAP) TO CP I/O INTERFACE
CIOP
212
REDUNDANT TDM
REDUNDANT MCAP
204
205
203
GPROC
GPROC
(Q)MSI
(Q)MSI
206
SERIAL INTERFACE
SERIAL INTERFACE
209
209
N64 Kbps RS-449
N64 Kbps RS-449
2.048 Mbps SPENS
2.048 Mbps SPENS
A+ INTERFERENCE
TO OTHER CIOP THELVES
TO OTHER CIOP THELVES
B INTERFERENCE
200
118

FIG. 2

BASIC MOBILE TO LAND CALL, ANSWERED, LAND DISCONNECT FIRST
MOBILE REGISTERED

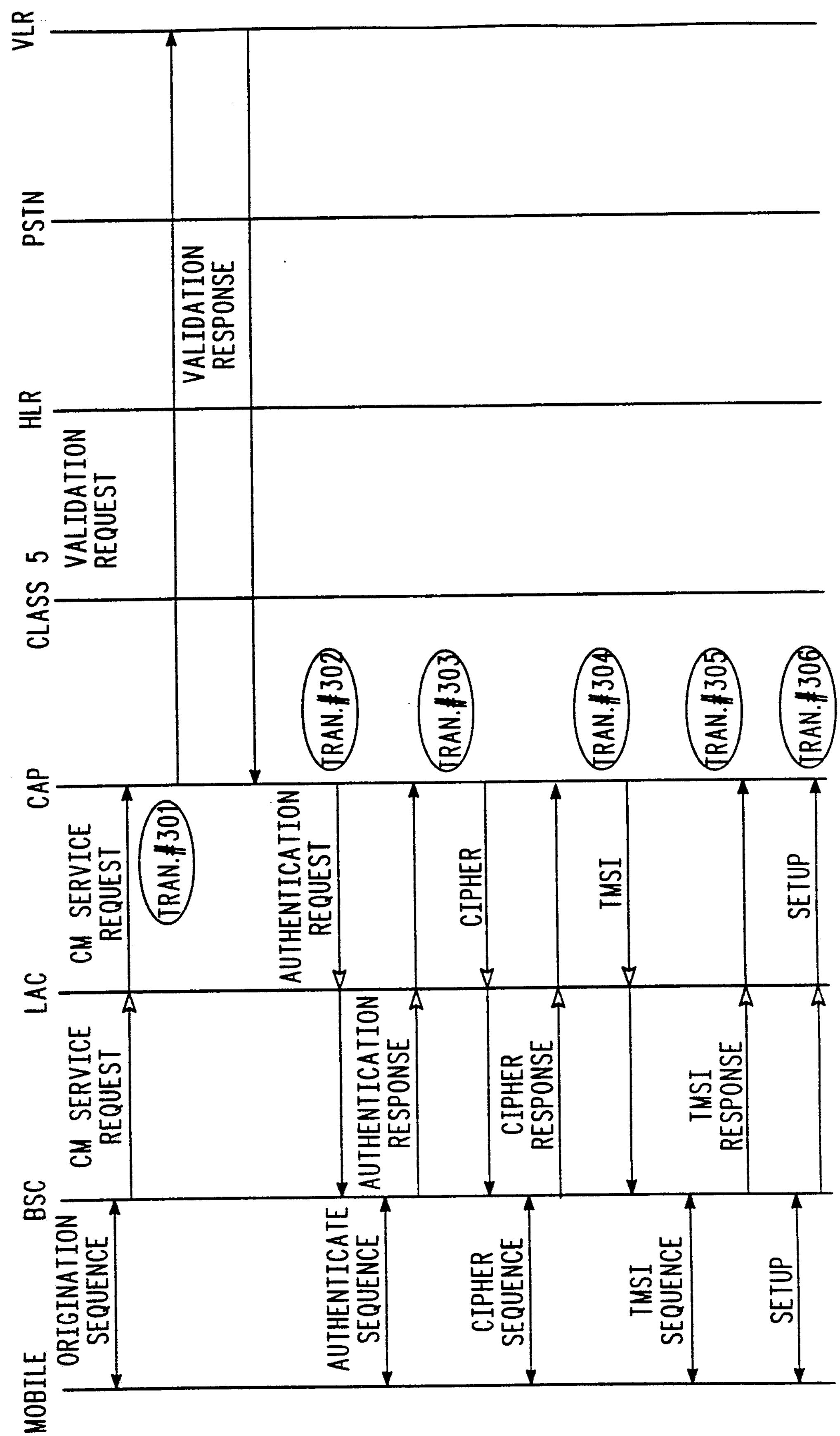


FIG. 3A

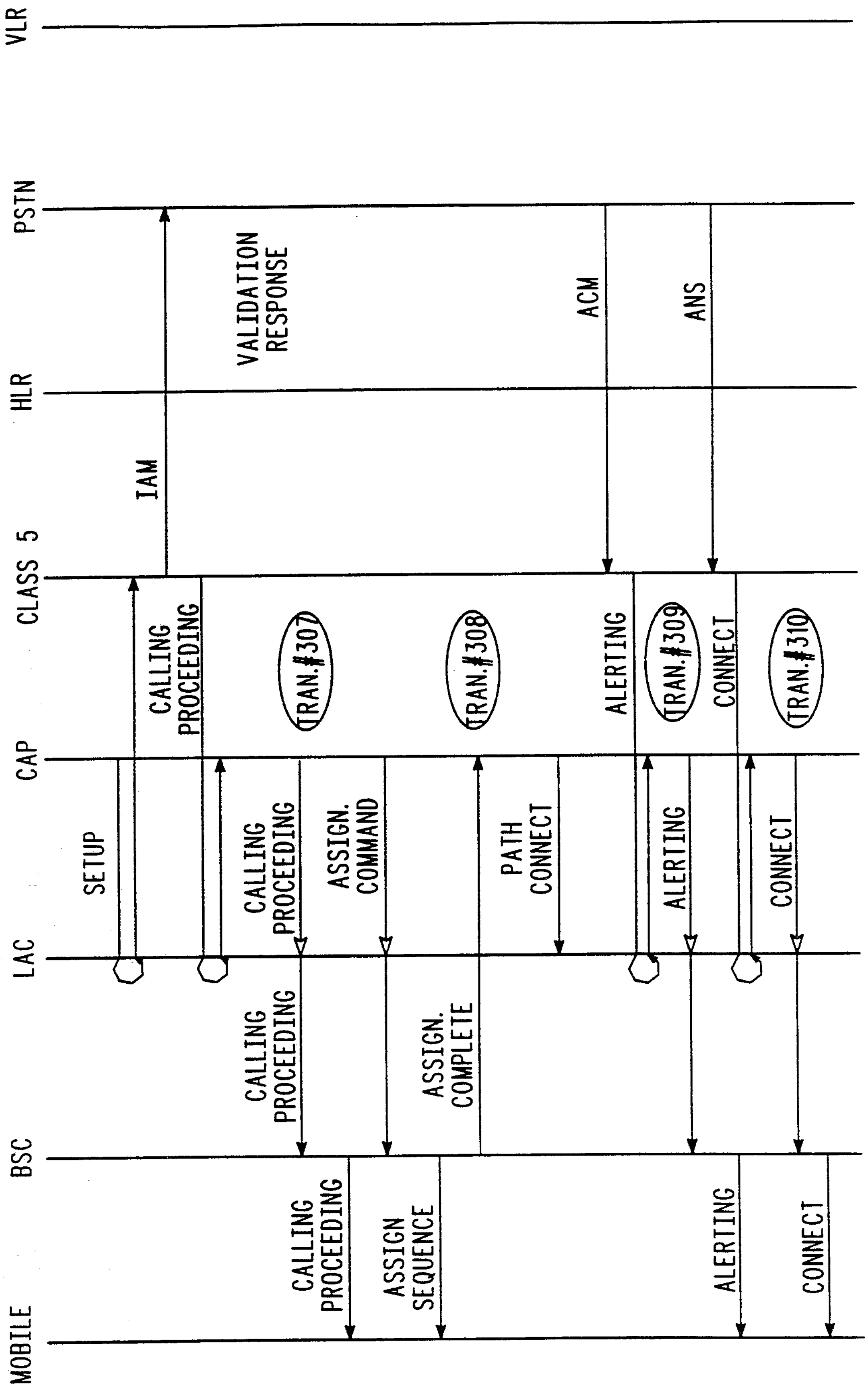

VLR
PSTN
HLR
CLASS 5
CAP
LAC
BSC
MOBILE
IAM
VALIDATION RESPONSE
ACM
ANS
SETUP
CALLING PROCEEDING
TRAN.#307
TRAN.#308
ALERTING
TRAN.#309
CONNECT
TRAN.#310
CALLING PROCEEDING
ASSIGN. COMMAND
PATH CONNECT
ALERTING
CONNECT
CALLING PROCEEDING
ASSIGN. COMPLETE
CALLING PROCEEDING
ASSIGN SEQUENCE
ALERTING
CONNECT

FIG. 3B

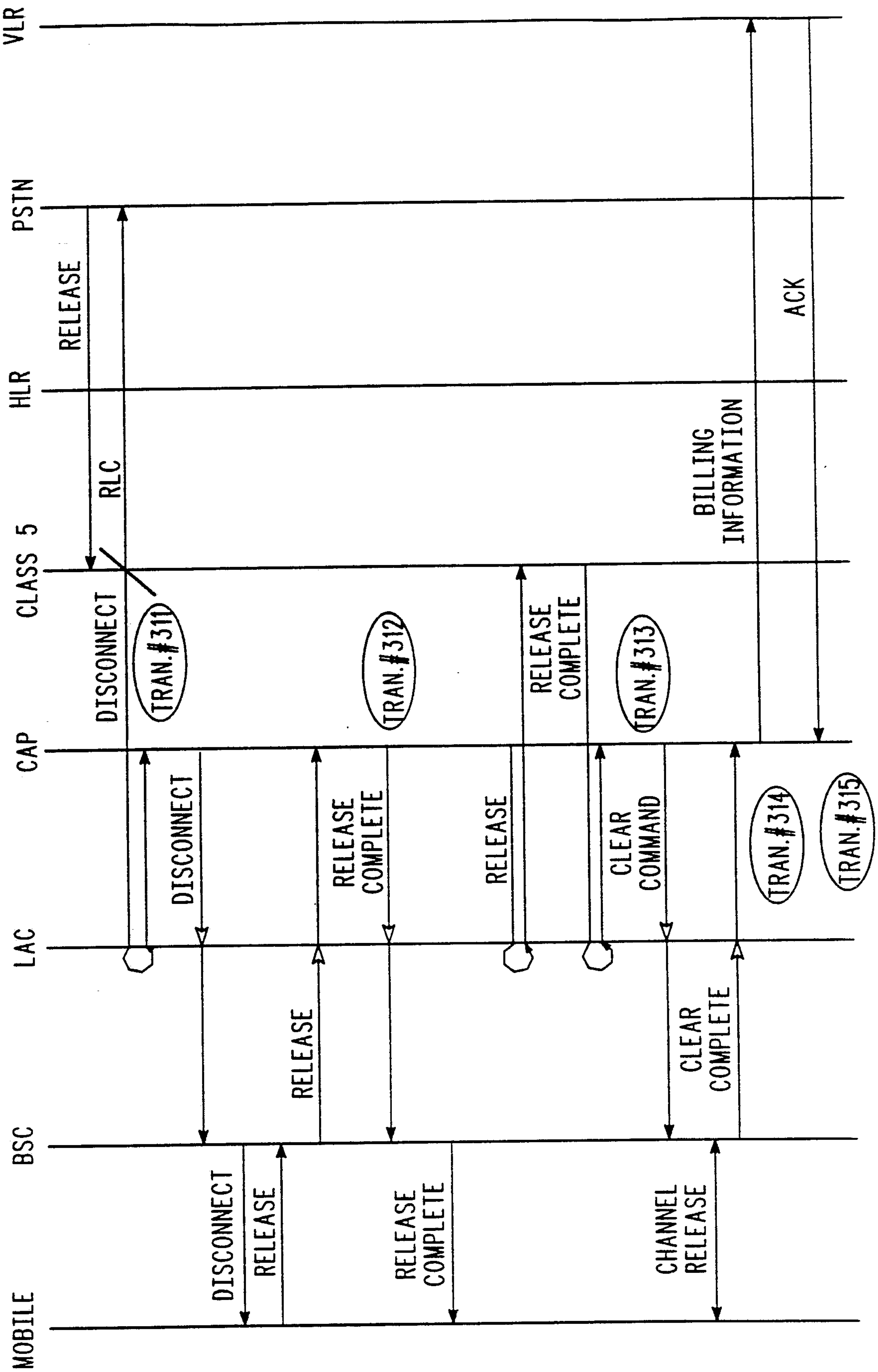

VLR
PSTN
HLR
CLASS 5
CAP
LAC
BSC
MOBILE
RELEASE
RLC
DISCONNECT
TRAN.#311
TRAN.#312
TRAN.#313
TRAN.#314
TRAN.#315
RELEASE COMPLETE
BILLING INFORMATION
ACK
DISCONNECT
RELEASE COMPLETE
RELEASE
CLEAR COMMAND
RELEASE
CLEAR COMPLETE
DISCONNECT
RELEASE
RELEASE COMPLETE
CHANNEL RELEASE

FIG.3C

BASIC LAND TO MOBILE CALL, ANSWERED, MOBILE DISCONNECT FIRST

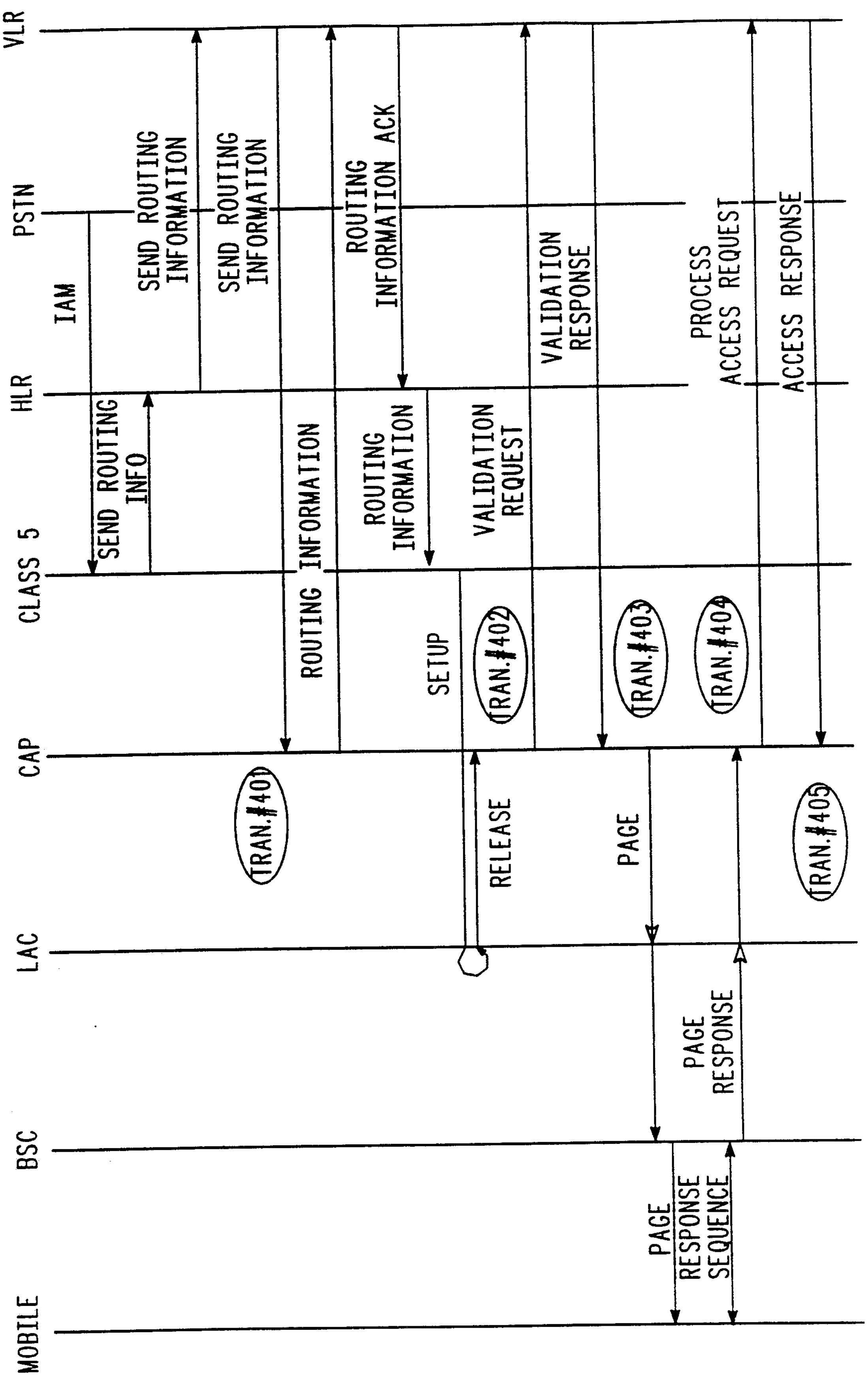


FIG. 4A

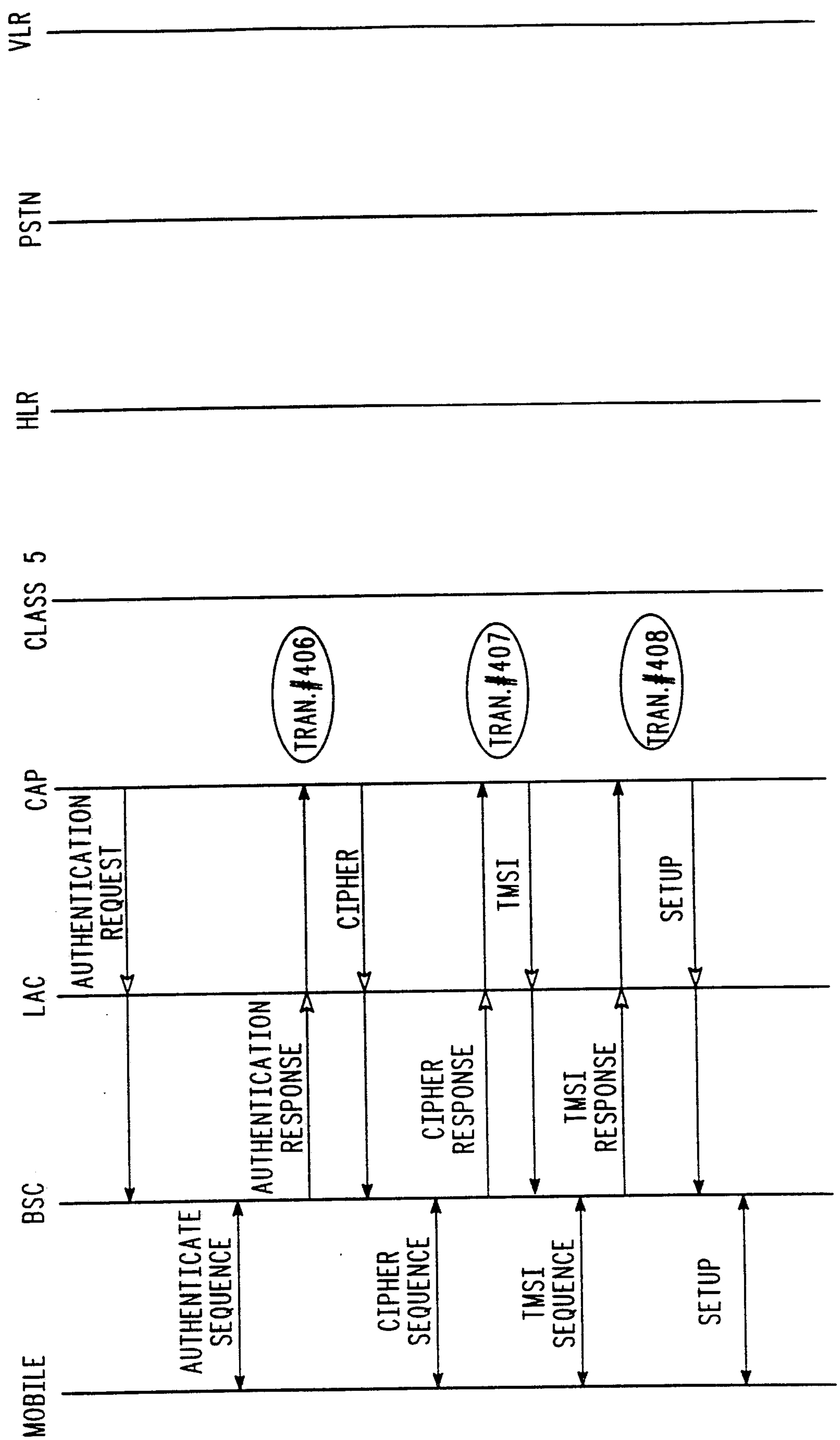

VLR
PSTN
HLR
CLASS 5
CAP
LAC
BSC
MOBILE
TRAN.#406
TRAN.#407
TRAN.#408
AUTHENTICATION REQUEST
AUTHENTICATION RESPONSE
CIPHER
CIPHER RESPONSE
TMSI
TMSI RESPONSE
SETUP
AUTHENTICATE SEQUENCE
CIPHER SEQUENCE
TMSI SEQUENCE
SETUP

FIG.4B

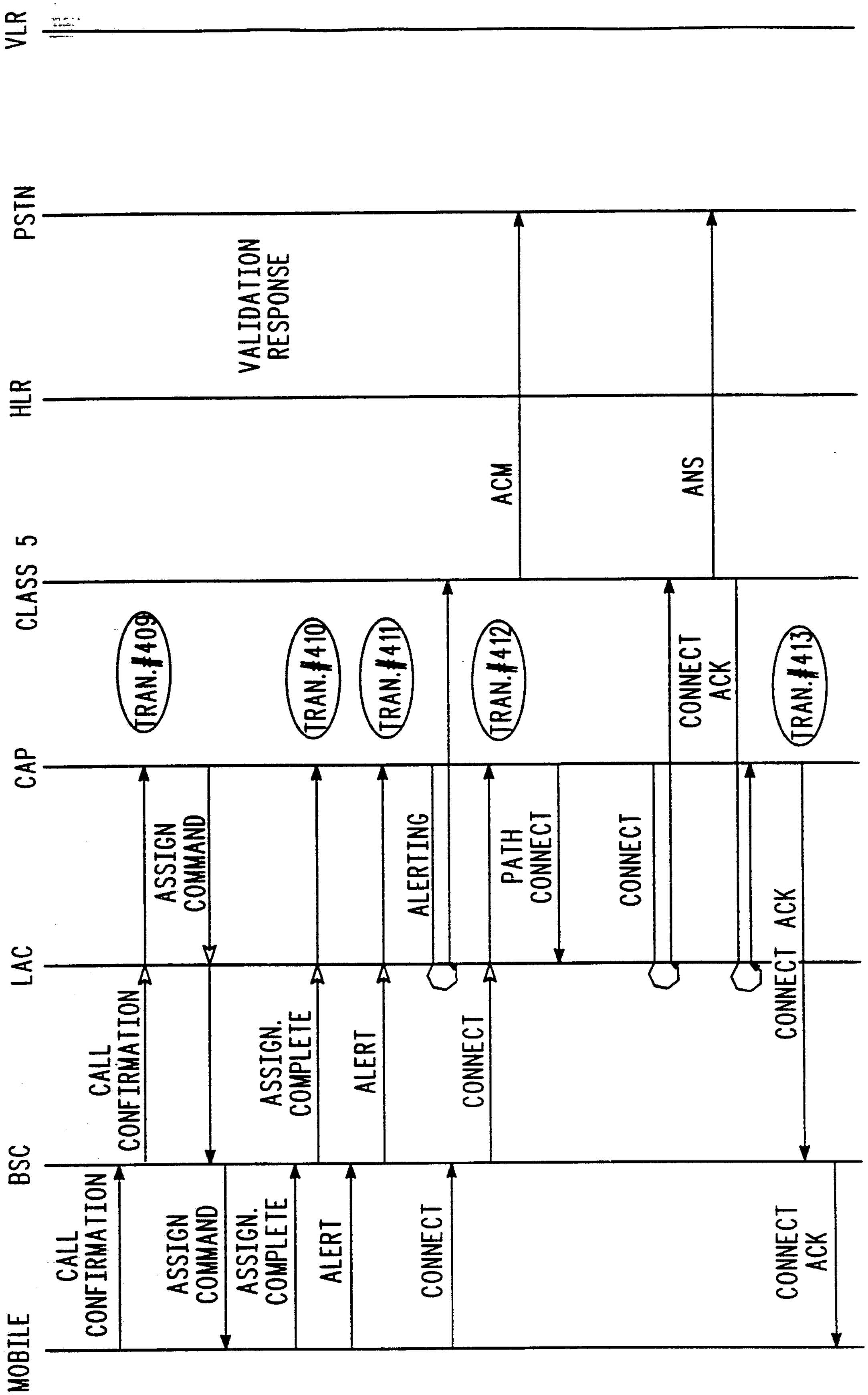
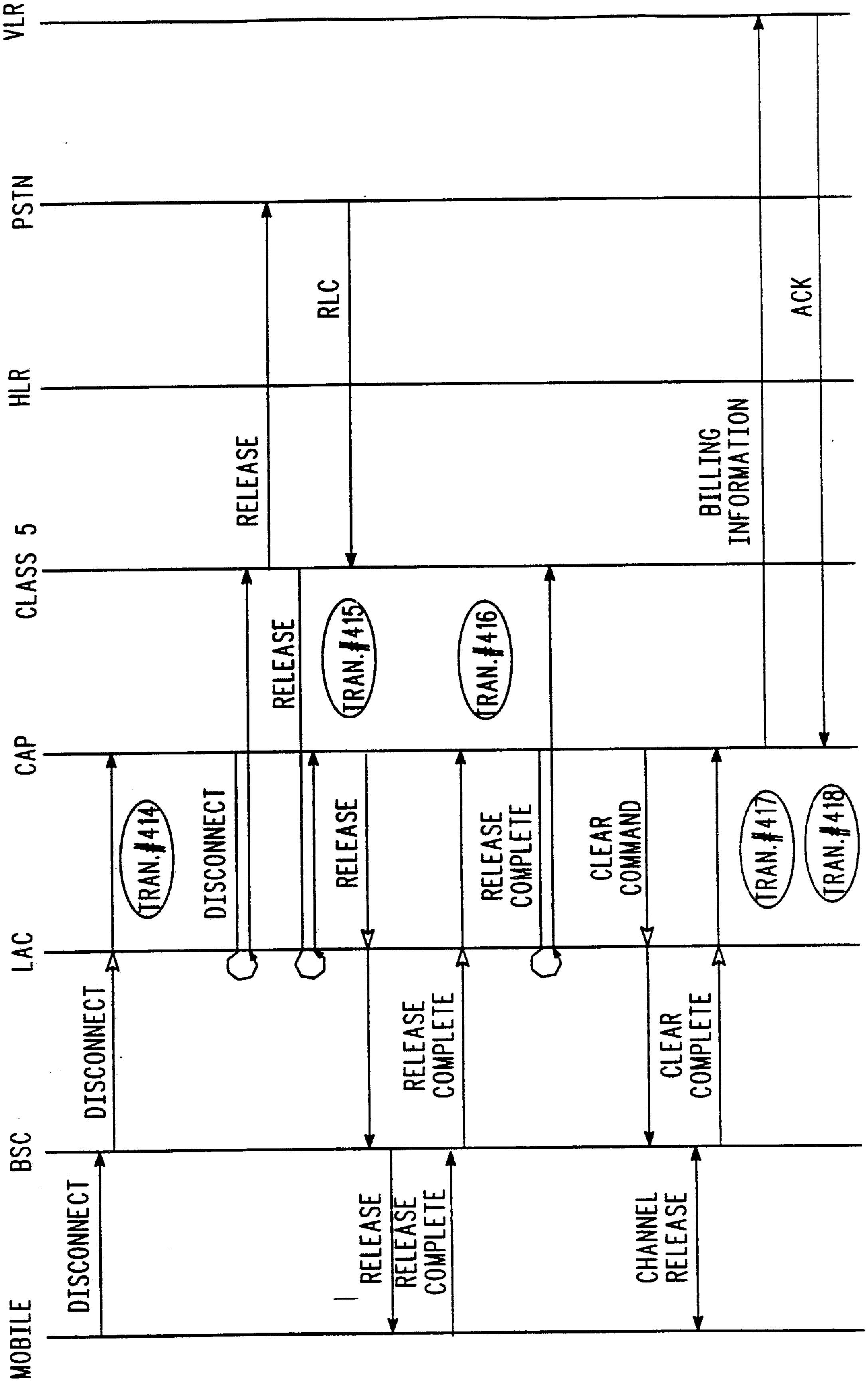

VLR
PSTN
HLR
CLASS 5
CAP
LAC
BSC
MOBILE
VALIDATION RESPONSE
ACM
ANS
TRAN. #409
TRAN. #410
TRAN. #411
TRAN. #412
TRAN. #413
CONNECT ACK
ASSIGN COMMAND
ALERTING
PATH CONNECT
CONNECT
CONNECT ACK
CALL CONFIRMATION
ASSIGN. COMPLETE
ALERT
CONNECT
CONNECT ACK
CALL CONFIRMATION
ASSIGN COMMAND
ASSIGN. COMPLETE
ALERT
CONNECT
CONNECT ACK

FIG. 4C



MOBILE
BSC
LAC
CAP
CLASS 5
HLR
PSTN
VLR
DISCONNECT
DISCONNECT
TRAN.#414
DISCONNECT
RELEASE
RELEASE
RLC
TRAN.#415
RELEASE
RELEASE
RELEASE COMPLETE
RELEASE COMPLETE
TRAN.#416
RELEASE COMPLETE
CLEAR COMMAND
CLEAR COMPLETE
CHANNEL RELEASE
TRAN.#417
TRAN.#418
BILLING INFORMATION
ACK

FIG. 4D

LOCATION UPDATE (CURRENT VLR SAME AS PREVIOUS VLR)

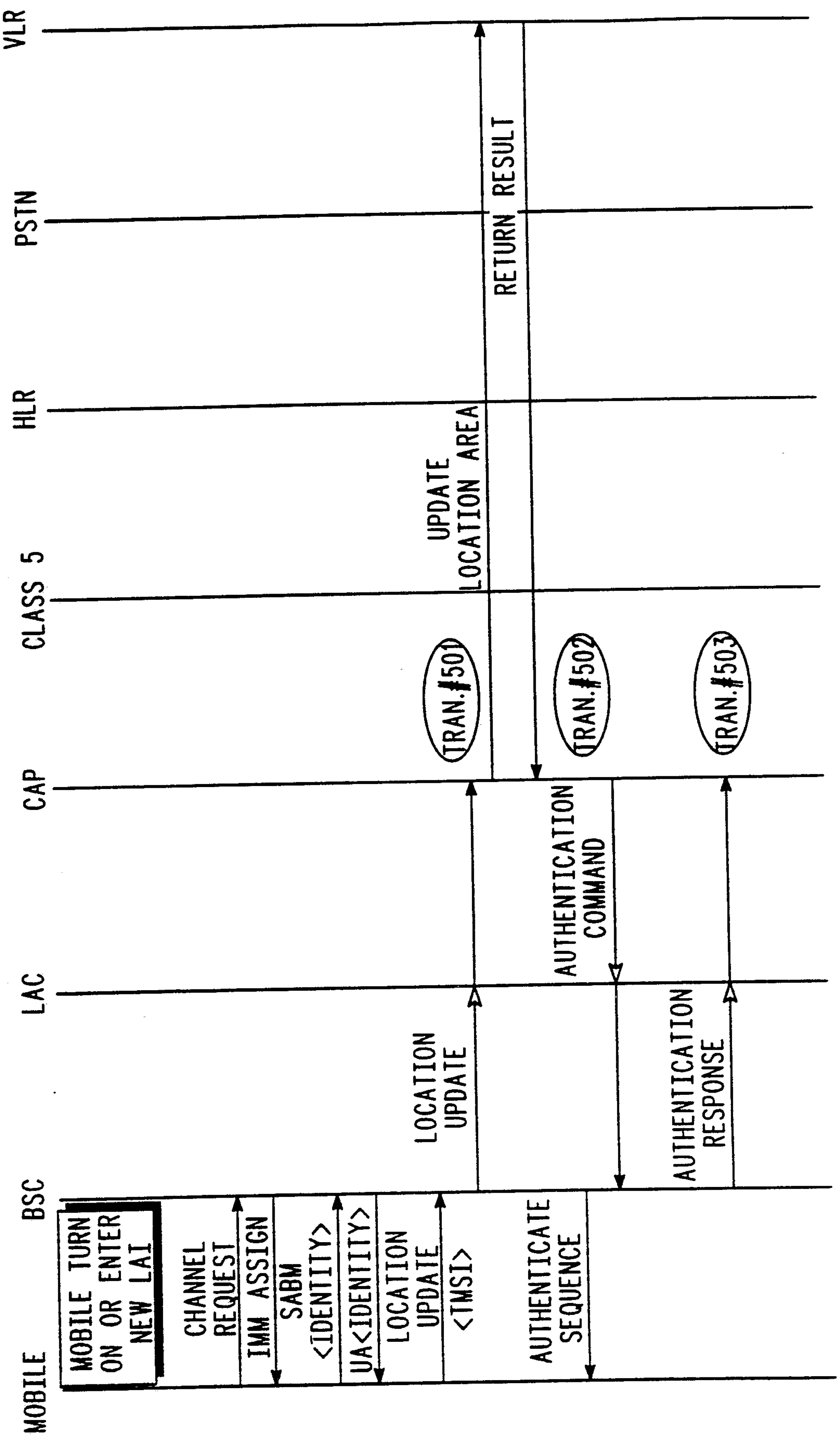


FIG. 5A

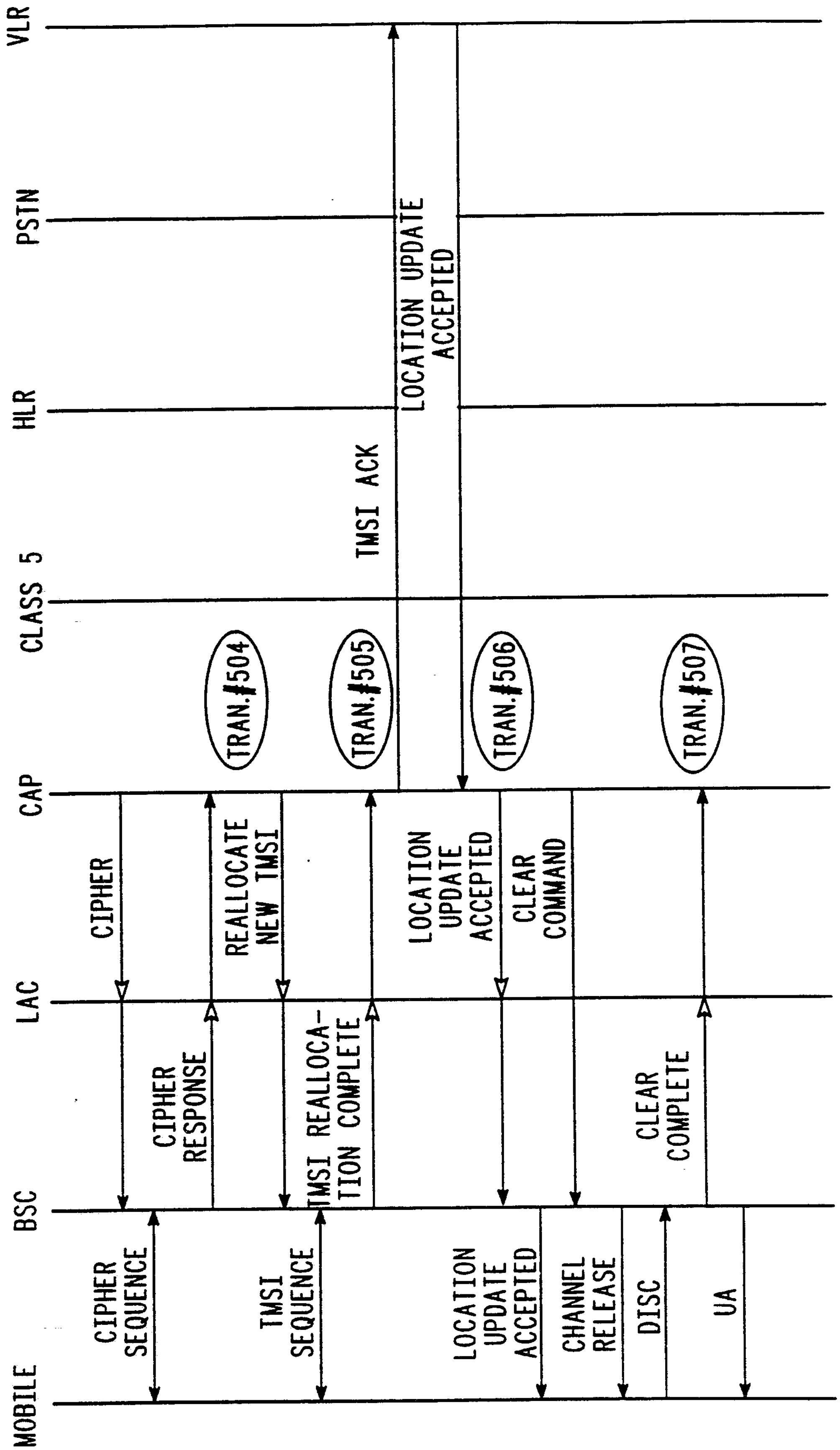

MOBILE
BSC
LAC
CAP
CLASS 5
HLR
PSTN
VLR
CIPHER SEQUENCE
TMSI SEQUENCE
LOCATION UPDATE ACCEPTED
CHANNEL RELEASE
DISC
UA
CIPHER RESPONSE
TMSI REALLOCATION COMPLETE
CLEAR COMPLETE
CIPHER
REALLOCATE NEW TMSI
LOCATION UPDATE ACCEPTED
CLEAR COMMAND
TRAN.#504
TRAN.#505
TRAN.#506
TRAN.#507
TMSI ACK
LOCATION UPDATE ACCEPTED

FIG. 5B

INTERNATIONAL SEARCH REPORT

PCT/US92/08674

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H04M 11/00
US CL :379/60
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 379/220,221

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPAT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US, A, 3,663,762 (JOEL, JR.) 16 May 1972, Note figures 1A and 1B.	1-3 4-10
X Y	US, A, 4,242,538 (ITO ET AL.) 30 December 1980, Note figure 2.	1-3 4-10
X Y	US, A, 4,475,010 (HUENSCH ET AL.) 02 October 1984, Note figure 2.	1-3 4-10
X Y	US, A, 5,018,187 (MARINHO ET AL.) 21 May 1991, Note figures 1,2,8,9.	4-7 1-3, 8-10
Y,P	US, A, 5,138,657 (COLTON ET AL.) 11 August 1992, Note figures 2,4,11a,11b,12,13a,13b.	1-10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

18 JANUARY 1993

Date of mailing of the international search report

01 FEB 1993

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US, A, 5,140,627 (DAHLIN) 18 August 1992, Note figures 3,4,6.	1-10